REMARKS

Claims 1 through 18 are pending in this application, of which claims 1 through 10 stand withdrawn from consideration pursuant to the provisions of 37 C.F.R. § 1.142(b). Accordingly, claims 11 through 18 are active.

The title has been changed consistent with the Examiner's suggestion, and the specification amended to address formalistic issues. Applicants submit that the present Amendment does not generate any new matter issue.

The Title

The Examiner asserted that the title is not descriptive and required a new title. In response, the title has been amended consistent with the Examiner's request.

Claims 11 through 18 were rejected under 35 U.S.C. § 103 for obviousness predicated upon Tang et al. in view of Chiras et al.

In the statement of the rejection the Examiner made clearly inaccurate factual determinations as to the teachings of the preliminary reference to Tang et al., particularly the formation of a **graded** tantalum nitride layer, and the manipulative step of **controlling** the **surface roughness** in any way. The Examiner then concluded that one having ordinary skill in the art would have been motivated to modify the surface roughness, nitrogen flow rate, and thickness ratio, in the method disclosed by Tang et al. in view of Chiras. The Examiner also asserted that the limitations of various claims which are not even in the case would have been obvious as a result of optimization. This rejection is traversed as factually and legally erroneous.

The Present Invention

The present invention relates to a method of manufacturing a semiconductor device which focuses on the interconnect structure. The claimed invention comprises a composite barrier layer with a controlled average surface roughness (Ra) of about 25 Å to about 50 Å on which copper is deposited. The applied prior art is conspicuously mute as to any suggestion of manipulating the **surface roughness** of a barrier layer prior to copper deposition.

Insufficient Facts

The applied prior art is totally deficient as to the requisite factual basis to support the obviousness conclusion. In the exposition of the rejection on page 3 of the September 1, 2005 Office Action, the Examiner asserted that Tang et al. disclose a method which comprises "...depositing a **graded** tantalum nitride layer (420, called seed layer) ..." (Emphasis supplied). **That statement is not accurate.**

It is not apparent wherein the method disclosed by Tang et al. comprises forming a **graded** tantalum nitride layer which Tang et al. refer to as a seed layer. Throughout the entire disclosure, including the paragraphs noted by the Examiner, Tang et al. refer to the seed layer as having a nitrogen content no greater than 33 at.%, typically less than about 25% at. There is no mention of the nitrogen content being graded.

The only mention of a graded nitrogen content relates to a **different** application noted by Tang et al. in paragraph [0007]. But that is not the method disclosed by Tang et al. in the actual applied reference upon which the Examiner relies.

To say that Tang et al. disclose a method corresponding to that claimed which comprises forming a graded tantalum nitride layer is wrong. To whatever extent the Examiner may have relied upon the doctrine of inherency, the Examiner should be aware that inherency requires **certainty**, not speculation. *Finnegan Corp. v. ITC, 180 F.3d 1354, 51 USPQ2d 1001 (Fed. Cir. 1999); In re Robertson, 169 F.3d 743, 49 USPQ2d 1949 (Fed. Cir. 1999); Electro Medical Systems S.A. v. Cooper Life Sciences, Inc., 34 F.3d 1048, 32 USPQ2d 1017 (Fed. Cir. 1994); In re Rijckaert, 9 F.3d 1531, 28 USPQ2d 1955 (Fed. Cir. 1993); Continental Can Co. USA, Inc. v. Monsanto Co., 948 F.2d 1264, 20 USPQ2d 1746 (Fed. Cir. 1991); W. L. Gore & Associates, Inc. v. Garlock, Inc., 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983).* There is no factual basis to support any inherency determination.

The above noted difference is not the only difference between the claim method and the method of Tang et al. **Specifically, Tang et al are completely mute as to any surface roughness on the exposed surface of the composite barrier layer.** It is the surface roughness that is **controlled** in accordance with the present invention, thereby reducing electro migration while preventing shadowing. See, for example, paragraph [0026] of the present disclosure.

The Examiner says, on page 4 of the September 1, 2005 Office Action, line 5, that Tang et al. disclose a method comprising "...**controlling** the surface roughness (Ra)" by varying ... the ratio of the thickness of the combined α-Ta and graded tantalum nitride layers to the thickness of the initial TaN layers; and/or (b) the N_2 flow rate during deposition of the TaN layer..." (Emphasis supplied). Applicants question: **Where?**

Applicants find **nothing** in Tang et al. about **controlling the surface roughness**. Applicants do not even find the words "surface roughness" mentioned in Tang et al. Applicants do not find any place where Tang et al. disclose controlling the surface roughness by

manipulating any variables, let alone the ratio of the thicknesses as in the claimed invention and/or the N_2 flow rate. The Examiner is hereby questioned as to precisely where Tang et al. disclose anything about the surface roughness, let alone controlling the surface roughness, let alone by controlling the surface roughness as in the claimed invention, notably claim 14 and Applicants separately advocate the patentability of claim 14 as well as **each claim**.

There is no motivation

The Examiner concluded that one having ordinary skill in the art would have been led to employ the nitrogen flow rate disclosed by Chiras et al. in implementing the methodology of Tang et al. This conclusion does not withstand scrutiny, because Tang et al. purposefully structure the tantalum nitride seed layer to have a **minimum controlled nitrogen content**. Further, it is not apparent wherein Chiras et al. disclose that the nitrogen flow rate should be manipulated to achieve any particular surface roughness. Accordingly, even if the applied references are combined as suggested by the Examiner, it is not apparent wherein the claimed method would result. *Uniroyal, Inc. v. Rudkin-Wiley Corp., 837 F.2d 1044, 5 USPQ2d 1434 (Fed. Cir. 1988).*

The missing result effective variable

As previously pointed out, **claim 11** is directed to a method which comprises forming a composite barrier layer with an exposed surface having an average surface roughness (Ra) of about 25 Å to about 50 Å lining an opening. The concept of a **surface roughness** on an exposed barrier layer surface is totally **absent** from the applied prior art. The concept of **controlling a surface roughness** is **absent** from the applied prior art. The concept of **controlling a surface**

roughness by the methods of the claimed invention, including claims 14, 15 and 16 are absent from the applied prior art.

Applicants separately argue the patentability of **claims 14, 15 and 16**. Since the concept of controlling the surface roughness is absent from the applied prior art, the surface roughness has not been identified as an art-recognized result effective variable. This being the case, it is legally erroneous to conclude that one having ordinary skill in the art would have been motivated to optimize the surface roughness or manipulate any parameters to achieve a particular surface roughness, because the surface roughness has not been identified as an art-recognized result effective variable. *In re Yates, 663 F.2d 1054, 211 USPQ 1149 (CCPA 1981); In re Antonie, 559 F.2d 618, 195 USPQ 6 (CCPA 1977); In re Rijckaert, 9 F.3d 1531, 28 USPQ2d 1955 (Fed. Cir. 1993).*

Evidence of Nonobviousness

It is well settled that the problem addressed and solved by a claimed invention must be given consideration in resolving the ultimate legal conclusion of obviousness under 35 U.S.C. § 103. *North American Vaccine, Inc. v. American Cyanamid Co., 7 F.3d 1571, 28 USPQ2d 1333 (Fed. Cir. 1993); Northern Telecom, Inc. v. Datapoint Corp., 908 F.2d 931, 15 USPQ2d 1321 (Fed. Cir. 1990); In re Newell, 891 F.2d 899, 13 USPQ2d 1248 (Fed. Cir. 1989); In re Nomiya, 509 F.2d 566, 184 USPQ 607 (CCPA 1975).* The present invention addresses and solves the problem of electromigration. Applicants found that the dominant Cu diffusion path for electro migration is along the Cu/barrier interface at the bottom and the side walls of the via electrically connecting upper and lower features. Applicants also recognized that the Cu diffusion path along the interface is heavily dependent upon, inter alia, the surface roughness of the Cu/barrier

interface. Further, there is a limit to the surface roughness otherwise a shadowing effect occurs during subsequent deposition resulting in Cu discontinuities. See, for example, paragraph [25] of the present application.

Applicants address and solve that problem by controlling the surface roughness (Ra) within a range of 25 Å to about 50 Å. The notion of electro migration resistance, the notion of electro migration occurring at the Cu/barrier interface, the notion of electro migration being dependent upon surface roughness, and the shadowing effect, are all concepts that don't even rise to a blip on the radar screens of the applied references.

Applicants finding as to the dependence of electromigration on the surface roughness is itself an indicia of **nonobviousness**. *In re Sponnoble, 405 F.2d 578, 160 USPQ 237 (CCPA 1969).* Moreover, the failure of the prior art to recognize, address or much less offer a solution to the electromigration problem, within the constraints of the shadowing effect, constitutes another potent indicium of **nonobviousness** which must be given consideration.

Conclusion

Based upon the foregoing it should be apparent that a *prima facie* basis to deny patentability to the claimed invention under 35 U.S.C. § 103 has not been established for the lack of the requisite factual basis and want of the requisite realistic motivation. Moreover, upon giving due consideration to the problem elements discussed above, as potent indicia of **nonobviousness**, the conclusion appears inescapable that one having ordinary skill in the art would **not** have found the claimed subject matter **as a whole** obvious within the meaning of 35 U.S.C. § 103. *Jones v. Hardy, 727 F.2d 1524, 220 USPQ 1021 (Fed. Cir. 1984).*

Applicants, therefore, submit that the imposed rejection of claims 11 through 18 under 35 U.S.C. § 103 for obvious predicated upon Tang et al. in view of Chiras et al. is not factually or legally viable and, hence, solicit withdrawal thereof.

Based upon the foregoing it should be apparent that the imposed rejection has been overcome and that all active claims are in condition for immediate allowance. Favorable consideration is, therefore, solicited.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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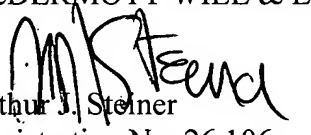

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